A GUIDE TO

ABAG'S

EARTHQUAKE HAZARD MAPPING

CAPABILITY

REVISED DECEMBER 1983

This guide was financed in large part by U.S. Geological Survey Contract Nos. 14-08-0001-17751, -19108, -19831 and -21226. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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ACKNOWLEDGEMENTS:

We would like to thank those many people at USGS and working for cities and counties in the Bay Area who took the time to review the many papers that form the basis for this guide.

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INTRODUCTION

PURPOSE

Since February 1979, ABAG has been developing a series of computer-based map files showing various basic data maps related to earthquakes and several maps derived from those illustrating various earthquake hazards. The project was started for two reasons:

- o to provide information that could be used by local governments in their seismic safety and safety programs.
- o to provide an input to various other planning programs at ABAG.

FORMAT

This project, unlike many that result in the publication of a final report, will be continuing and various map files will be expanded or upgraded. Therefore, this guide has been designed as a loose-leaf folder so that pages or sections can be replaced or added as ABAG's earthquake hazard mapping capability changes and expands.

The guide contains this introduction and three main sections:

- o a set of sheets describing each of the basic data map files and a cover sheet for that section
- o a set of sheets describing each of the hazard map files and a cover sheet for them.
- o a set of sheets describing several applications for the map files (also with a cover sheet).

The guide has also been designed to include a set of the working papers that have been developed to further describe the assumptions that were made and the data used to develop the hazard maps. A sheet summarizing the Working Papers is at the end of the report.

MAP DEVELOPMENT PHASES

The first phase of the mapping project focused on developing an operational earthquake hazard mapping capability and demonstrating some sample uses for researchers and local government technical staff. Files of basic data maps on generalized geology (four bedrock categories), faults, and dam failure and tsunami inundation areas were compiled for the entire nine-county Bay Area. Detailed information on hillside geology, as well as data on landslide deposits and topography, were compiled only for San Mateo County due to the expense of entering these data into the computer system. These basic data map files were manipulated to produce a series of hazard map files for the region or San Mateo County; including:

- o maximum ground shaking intensity;
- o cumulative risk of damage from ground shaking;
- o liquefaction susceptibility, both earthquake-induced and rainfall-induced;
- o dam failure and tsunami inundation; and
- o composite maps combining all these hazard maps.

The detailed ground shaking maps, landslide susceptibility maps and composite maps were produced only for San Mateo County.

The second phase expanded the area for which detailed hillside geology, landslide deposits and topographic information is in ABAG's computer data base by fifteen 7 1/2 minute quadrangles. These areas--Petaluma and its vicinity, and parts of the east Bay ridgelands of Santa Clara, Alameda and Contra Costa counties--were chosen as areas subject to extensive development pressure. The detailed basic data maps were used to develop more refined maximum ground shaking and risk maps, landslide susceptibility maps, and composite maps. These maps, together with those developed in the first contract, then were used in sample applications in local general plans, to provide computer-derived background reports for Environmental Impact Reports (EIRs), to screen areas for possible sites for key facilities, and to assess the vulnerability of existing and projected land uses and population to damage from a major earthquake.

The third phase focused on lifeline networks in the Bay Area, including major highways and railroads, electrical and gas networks, water supply aqueducts, and solid waste systems. Since lifeline problems are located largely in areas of existing urban development, this work is a logical complement to the second phase work, which focused on areas subject to rapid new development. Detailed information on hillside geology, landslide deposits, and topography was added to ABAG's computer data base for fifteen additional quadrangles in the central Bay Area. Again, the detailed basic data maps were used to develop more refined maximum ground shaking and risk maps and landslide susceptibility maps. These maps then will be used to provide detailed information on physical hazards, not structural hazards, associated with the location of these lifeline systems. The audience for these products is being broadened to include people and agencies operating and regulating lifeline systems, as well as local government staff.

The fourth and most recent phase of the mapping has sought to correct some major inadequacies of previous work. Therefore, ABAG has expanded the area for which detailed mapping of geological materials is available in digital form to cover all nine Bay Area counties. In addition, fault trace and fault study zone mapping available in July 1983 has been incorporated into ABAG's existing computer files of these data. The fault and geology files then have been combined with seismologic data on ground shaking attenuation, the effects of local geology on intensity, and the recurrence intervals of major earthquakes to refine the ground shaking risk maps produced in earlier phases, as well as to produce a

series of intensity maps for selected earthquake events. Finally, a series of maps showing hazards associated with liquefaction, dam failure and tsunami inundation (based on work in previous project phases) similar in format to the ground shaking intensity maps has been produced at a scale appropriate for most users for comparison with those intensity maps. ABAG has continued its successful program of extensive documentation and user interaction to ensure the continued and appropriate use of these maps by federal, state and local government, other ABAG programs, transportation and utility groups, and the private sector.

EARTHQUAKE MAPPING AND ABAG'S EARTHQUAKE PREPAREDNESS PROGRAM

ABAG'S concerns about earthquake safety grew out of three separate, but related, programs. ABAG served as a liaison with other regional planning agencies and with county and local governments in the San Francisco Bay Region Environment and Resources Planning Study. The study, begun in January 1970, was jointly sponsored by the U.S. Geological Survey and the Department of Housing and Urban Development. ABAG completed a report for this study in February 1976, Quantitative Land Capability Analysis - A Method of Applying Earth Science Information to Planning and Decision Making. The report describes the use of benefit-cost analysis in weighing the relative importance of selected earth science hazards, constraints and resources. The report was published as U.S.G.S. Professional Paper 945 in 1979.

During the same period, ABAG prepared a booklet entitled Hazards Evaluation for Disaster Preparedness Planning summarizing the results of a study on evaluating hazards sponsored by the Defense Civil Preparedness Agency of the Department of Defense, completed in August 1975. The project focused on developing a standard method for evaluating earthquakes and several other natural and man-made sources of disasters.

The findings of these reports, as well as other related information, were given to ABAG's member governments in February, 1976 at a General Assembly entitled "On Shaky Ground". ABAG's General Assembly indicated that a program to help prepare the region for coping with major earthquakes is extremely important. Such a program also has been supported by ABAG's Executive Board, Work Program and Coordination Committee and various other committees.

These desires led to the revision of ABAG's General Plan to include several objectives dealing with improving seismic safety and a series of actions to accomplish these objectives focusing on:

- o incorporating seismic safety concerns into ABAG's plan and project review function
- o supporting or advocating legislation at the State and federal level

- o providing assistance to ABAG's member governments in improving their safety and seismic safety programs

The service activities have led to several recent projects, including:

- o a survey of local regulations related to geologic and hydrologic hazards, constraints and resources
- o a survey of geotechnical study costs
- o a review of earthquake insurance issues
- o an extensive review of the liability of local government, as well as businesses and industries, for earthquake hazards and losses

The study of local government liability also resulted in ABAG's advocacy of State legislation that was passed by the legislature and signed by the Governor in 1979.

This earthquake mapping project is providing strong technical support for the Earthquake Preparedness Program. It is enabling ABAG staff to conduct land capability type analyses not only for all nine Bay Area counties, but also at the fine resolution of one hectare (2-1/2 acres).

These overlaying and modeling capabilities are extremely important not only for creating the hazard maps in the first place, but also for combining earthquake hazard concerns with other physical and social constraints for site evaluation and impacts analyses.

EARTHQUAKE MAPPING AND THE BAY AREA SPATIAL INFORMATION SYSTEM (BASIS)

This project is closely tied to ABAG's BASIS program. A major objective of BASIS is to develop a regional geographic data base that can be directly used in local, as well as regional, planning applications. It was developed to tie together the data development and map analysis different computers and different resolutions. (The land capability study that used a system at the University of California at Davis was one such application.)

BASIS is structured around an array of grid cells, each representing a land area of one hectar (100 meters square) in the UTM coordinate system. It requires over two million of these cells to cover the nine-county Bay Region. Each cell on the ground corresponds to one unit of computer storage; the unit contains data codes representing the characteristics of that cell. Data can be acquired either by reading a tape or by digitizing a map. BASIS is capable of using data based on other coordinated systems (such as longitude/latitude or LANDSAT reference points) by mathematically transforming these reference systems to a common UTM base. This project greatly increases the data available for each cell. The basic data map files listed in the main body of this guide are a product of direct data acquisition.

Much of the power of BASIS lies in its ability to manipulate the basic data map files. A composite of many data sets can be produced through an overlay or modeling process, and can include distance searches or other calculations. Most of the hazard map files are the product of these processes.

BASIS currently runs on Geogroup Corporation's computer system, which can handle data transfer to or from most other computer systems. The computer configuration includes a digitizer for encoding mapped data, an electrostatic plotter for producing computer maps, a small format 8-color pen plotter, and a printer. The present computer system (developed by Convergent Technologies) is a cluster of two work stations, each of which contains a processor and 256K bytes of memory. Data storage is presently on one 20M byte disk. A nine-track tape drive and standard floppy disks are used for file back-up and data transfer. Geogroup staff are responsible for all programming work.

BASIS DATA MAP FILES

As of December 1983, the earthquake hazard maps are based on six basic data map files described on the following pages:

- o geology (ozalid copies available at 1:250,000)
- o fault traces (ozalid copies available at 1:250,000)
- o topography
- o landslides
- o tsunami inundation areas
- o dam failure inundation areas (ozalid copies available at 1:250,000)

In addition, a land use file, and files of selected lifeline systems, have been created to illustrate some applications.

Each of the following sheets consists of five major sections describing various aspects of the map file on the front. The five sections include:

- o Coverage - the area of the region covered (including a map) and the resolution of the data
- o Source - the scale and name of the source used (if many sources are used a working paper containing the complete list may be referenced)
- o Major categories on map - the categories in the file are listed to the extent practicable
- o Used with other files to produce hazard files on - a cross-reference to the hazard map files using this basic data file
- o Limitations and future plans - limitations in coverage or accuracy are described, together with future plans to upgrade each file

A 1:1 million scale reproduction of the file appears on the back for illustration only. At this scale, a complete map explanation would be meaningless. Potential users should contact ABAG staff to obtain maps of their area of interest and an explanation for those maps.

There are other basic files in BASIS that have not been improved in conjunction with this earthquake mapping project. These files can be divided into two categories, files depicting the physical environment and those depicting the social environment:

PHYSICAL ENVIRONMENT

- o average annual precipitation - region-wide
- o vegetation - region-wide
- o National Flood Insurance Program maps - unincorporated areas and some cities
- o flood-prone areas defined by U.S.G.S. in 1972 - region-wide
- o coastline features from U.S.G.S. 7-1/2 minute quadrangles - region-wide
- o soil associations (generalized from soils types) - region-wide
- o average yield from wells - region-wide
- o digital terrain tape elevations - region-wide
- o slope stability (generalized to 25 hectare resolution) - region-wide
- o air quality problem areas - region-wide

SOCIAL ENVIRONMENT

- o 1970 census tracts - region-wide (1980 census tracts are available for selected applications)
- o county boundaries - region-wide
- o city sphere-of-influence boundaries - region-wide
- o airports, seaports, vacant industrial lands - region-wide
- o landfill sites and service areas

GEOLOGY

BASIC DATA MAP FILE

COVERAGE: All Bay Area counties in great detail

SOURCE:
SCALE: 1:62,500 and 1:24,000 (for bedrock geology) and 1:125,000 (for flatlands deposits)
NAME: U.S.G.S. Professional Paper 944--Flatlands deposits of the S.F. Bay Area; Geology Maps by various U.S.G.S. and C.D.M.G. authors (see Working Paper #17 for more information).

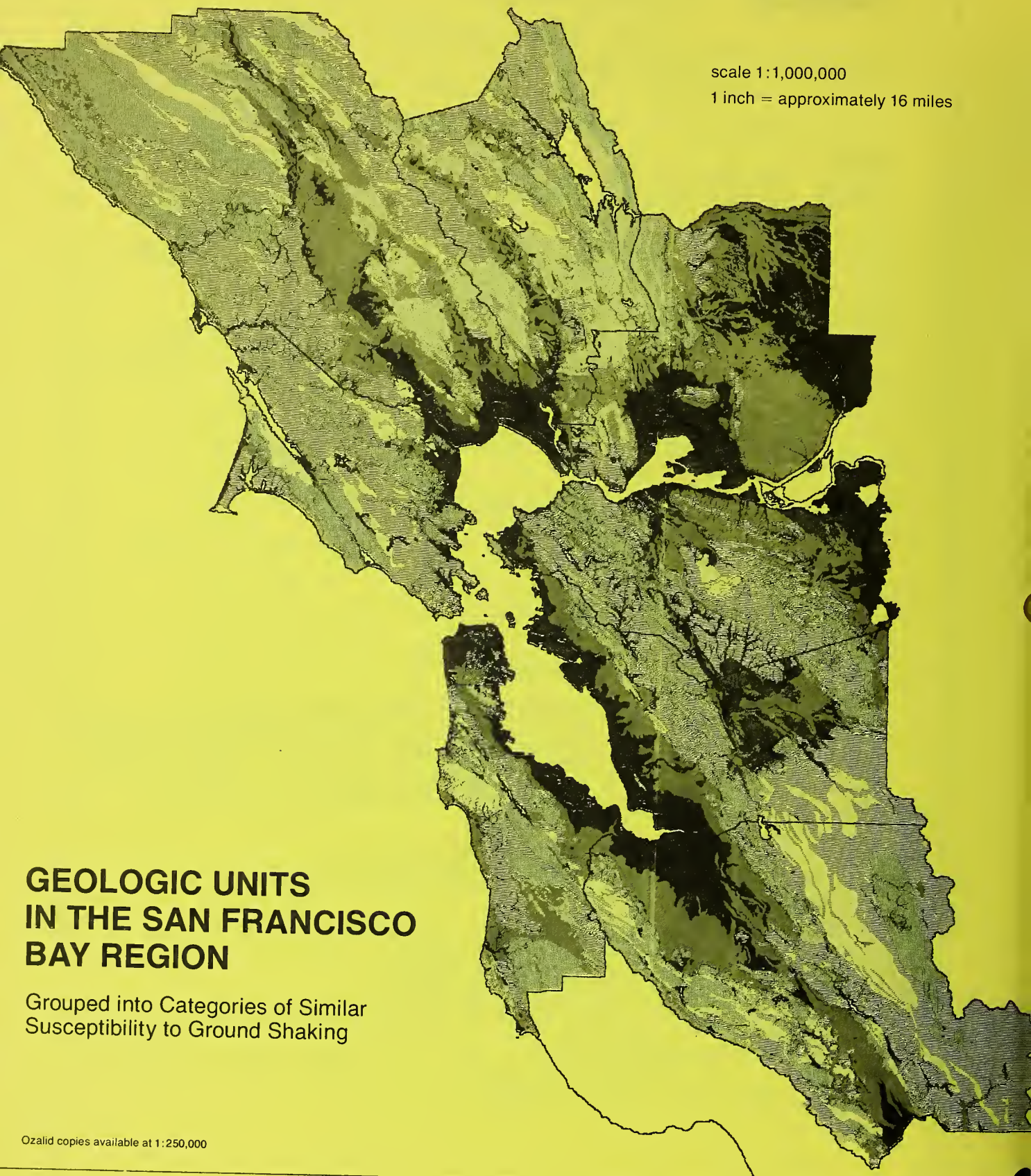
December 1983
Hectare resolution

MAJOR CATEGORIES ON MAP:
277 units, including:
- 26 Quaternary units (from the map of flatlands deposits);
- 16 Quaternary/Tertiary units
- 50 Tertiary (Pliocene) units
- 6 Tertiary (Pliocene/Miocene) units
- 20 Tertiary (Miocene) units
- 9 Tertiary (Miocene/Oligocene) units
- 5 Tertiary (Oligocene) units
- 29 Tertiary (Eocene) units
- 2 Tertiary/Eocene/Paleocene) units
- 10 Tertiary (Paleocene) units
- 8 Tertiary (Paleocene)/Cretaceous units
- 44 Cretaceous Units
- 22 Cretaceous/Jurassic units (largely Great Valley Sequence)
- 31 Cretaceous/Jurassic units (Franciscan Assemblage and small masses)

(These units have been grouped into 8 categories with similar seismic properties to produce the map on the back of this sheet. Darker shades are associated with units having a higher susceptibility to strong ground shaking.)

USED WITH OTHER FILES TO PRODUCE HAZARD FILES ON:
- o ground shaking intensity for selected scenario earthquakes
- o maximum ground shaking intensity
- o cumulative damage potential from earthquake ground shaking
- o liquefaction susceptibility and potential
- o rainfall-induced landslide susceptibility
- o earthquake-induced landslide susceptibility

LIMITATIONS AND FUTURE PLANS:
The geology file currently available is the state-of-the-art composite map for the San Francisco Bay Area.



scale 1:1,000,000
1 inch = approximately 16 miles

GEOLOGIC UNITS IN THE SAN FRANCISCO BAY REGION

Grouped into Categories of Similar Susceptibility to Ground Shaking

Ozalid copies available at 1:250,000

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FAULT TRACES

BASIC DATA MAP FILE

COVERAGE: All Bay Area counties and parts of adjacent counties

SOURCE:
SCALE: largely 1:24,000 with some at 1:60,000, 1:125,000, and 250,000
NAME: Fault traces shown on Special Studies Zones Maps prepared by the State Geologist and additional mapping of fault traces by U.S.G.S. personnel of faults they consider active or probable active.
(See Working Paper #17 for more information.

December 1983
Vector(line) resolution

MAJOR CATEGORIES ON MAP:

Antioch
Berrocal
Butano*
Calaveras
Concord
Cordelia
Coyote Creek
Dunnigan Hills
East of Santa Rosa
East of Bennett Valley
Evergreen
Faults near Trenton
Green Valley (incl. Hunting Creek)
Greenville
Hayward (including Cressly)
Healdsburg
Las Positas
Maacama
Midway
Monte Vista
Ortigalita
Piercy
Pleasanton
Rodgers Creek
San Andreas
San Gregorio
San Joaquin
Sargent
Serra
Shannon*
Silver Creek
Tolay
Verona
West Napa
Zayante

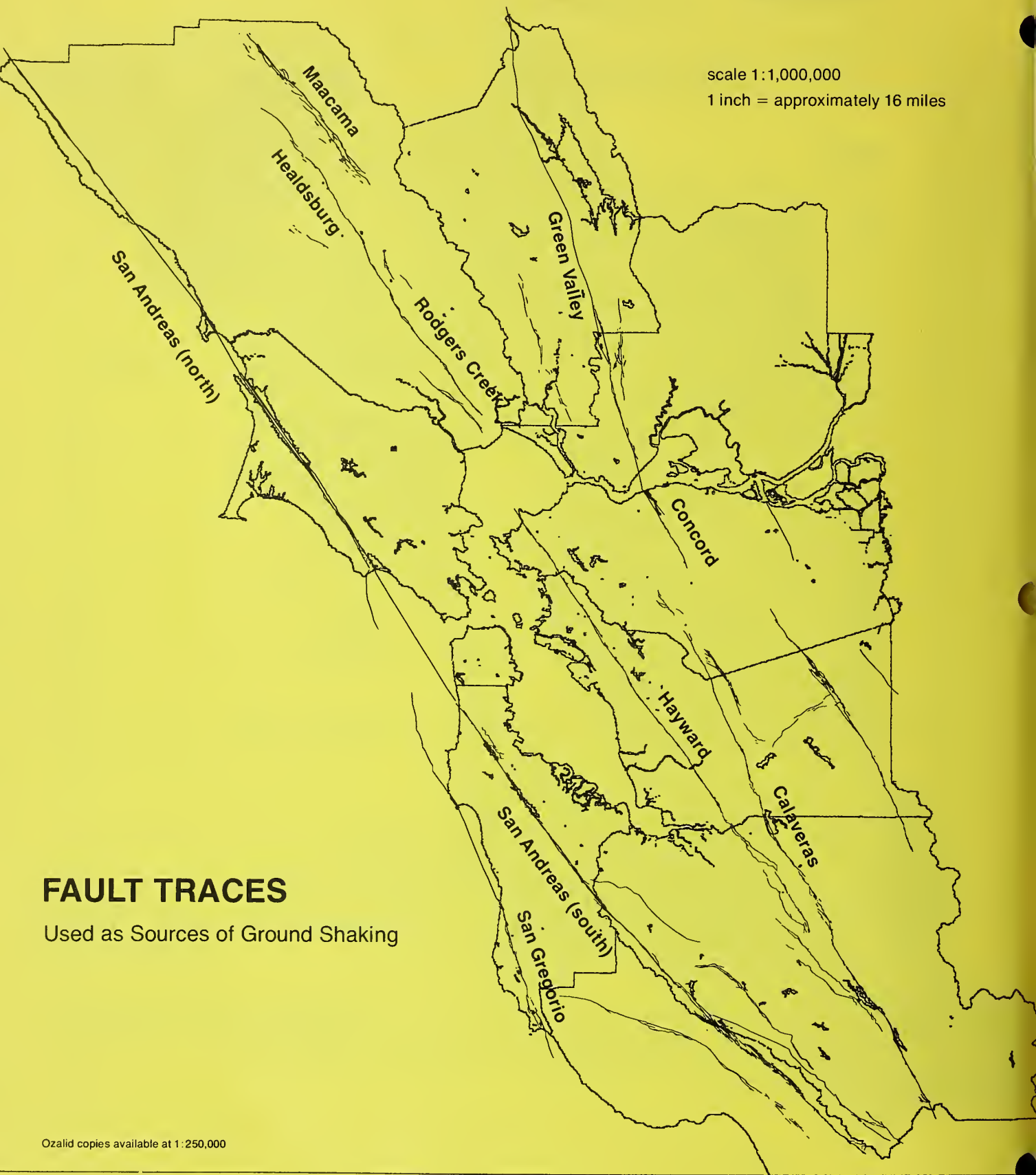
* Traces NOT included in intensity mapping and thus not shown on the back of this sheet.

USED WITH OTHER FILES TO PRODUCE HAZARD FILES ON:

- o ground shaking intensity for selected scenario earthquakes
- o maximum ground shaking intensity
- o cumulative damage potential from earthquake ground shaking
- o liquefaction potential
- o fault studies zones

LIMITATIONS AND FUTURE PLANS:

Changes in fault traces should be made as new information becomes available.



FAULT TRACES

Used as Sources of Ground Shaking

Ozalid copies available at 1:250,000

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HAZARD MAP FILES

As of December 1983, the first six basic data maps have been manipulated to create nineteen hazard map files and two of the basic maps (marked with *) are actually hazard files:

- o ground shaking intensity for ten selected scenario earthquakes (ozalid copies available at 1:250,000)
- o maximum ground shaking intensity (ozalid copies available at 1:250,000)
- o cumulative damage potential from earthquake ground shaking for three building types (ozalid copies available at 1:250,000)
- o liquefaction susceptibility (ozalid copies available at 1:250,000)
- o liquefaction potential (ozalid copies available at 1:250,000)
- o rainfall-induced landslide susceptibility
- o earthquake-induced landslide susceptibility
- o fault studies zones (ozalid copies available at 1:250,000)
- o *tsunami hazard areas
- o *dam failure hazard areas (ozalid copies available at 1:250,000)

Each of the following sheets consists of five major sections describing various aspects of the map files on the front. The five sections include:

- o Coverage - the area of the region covered (including a map) and the resolution of the data
- o Source - the basic data map files and the key assumptions used
- o Diagram of components a figure depicting how the basic data basic data map files are used to create the hazard map files
- o Further information on this file is contained in - a list of the working papers further describing the map development and, if applicable, other relevant documents (complete citations are not provided but can be obtained from the working papers)
- o Limitations and future plans - descriptions of limitations in coverage or accuracy, and any plans to upgrade the file.

A 1:1 million scale reproduction of the file appears on the back of each sheet. At this scale, an explanation of individual map categories is meaningless. Potential users should contact ABAG staff to obtain specially produced maps of their area of interest, any of the ozalid maps listed above, and an explanation for those maps.

GROUND SHAKING INTENSITY FOR SELECTED EARTHQUAKES

HAZARD MAP FILE

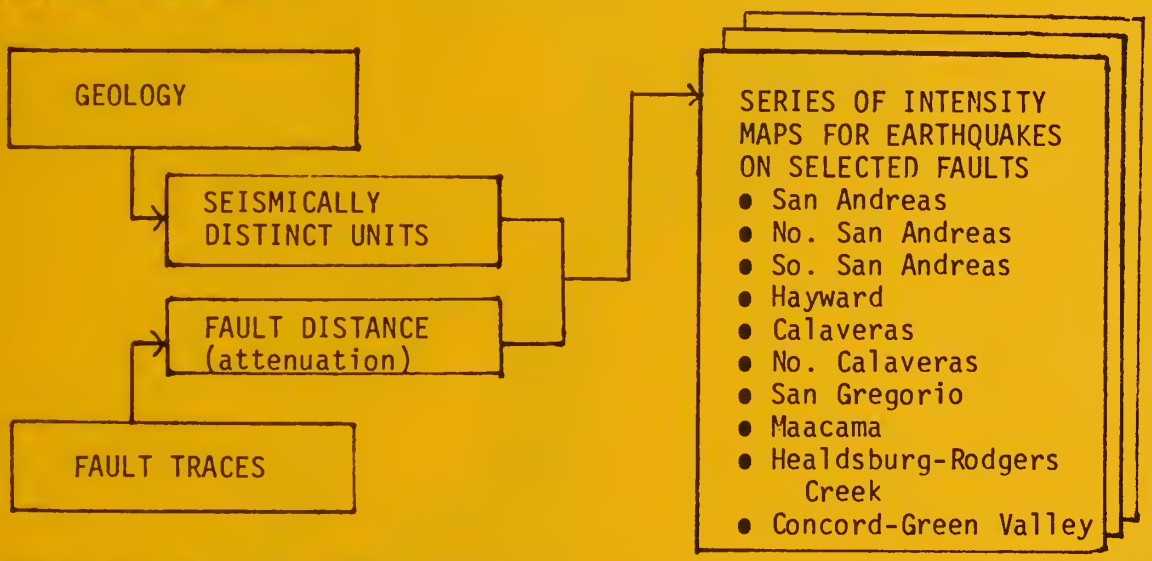
COVERAGE: All nine Bay Area counties in great detail

SOURCE: The basic data map files on faults and geology are combined to produce this map using data on:

- o magnitude associated with the source faults
- o maximum intensity associated with each magnitude
- o the attenuation of intensity with distance from the fault rupture
- o the effect of local geology on that intensity

December 1983
Hectare resolution

DIAGRAM OF COMPONENTS:



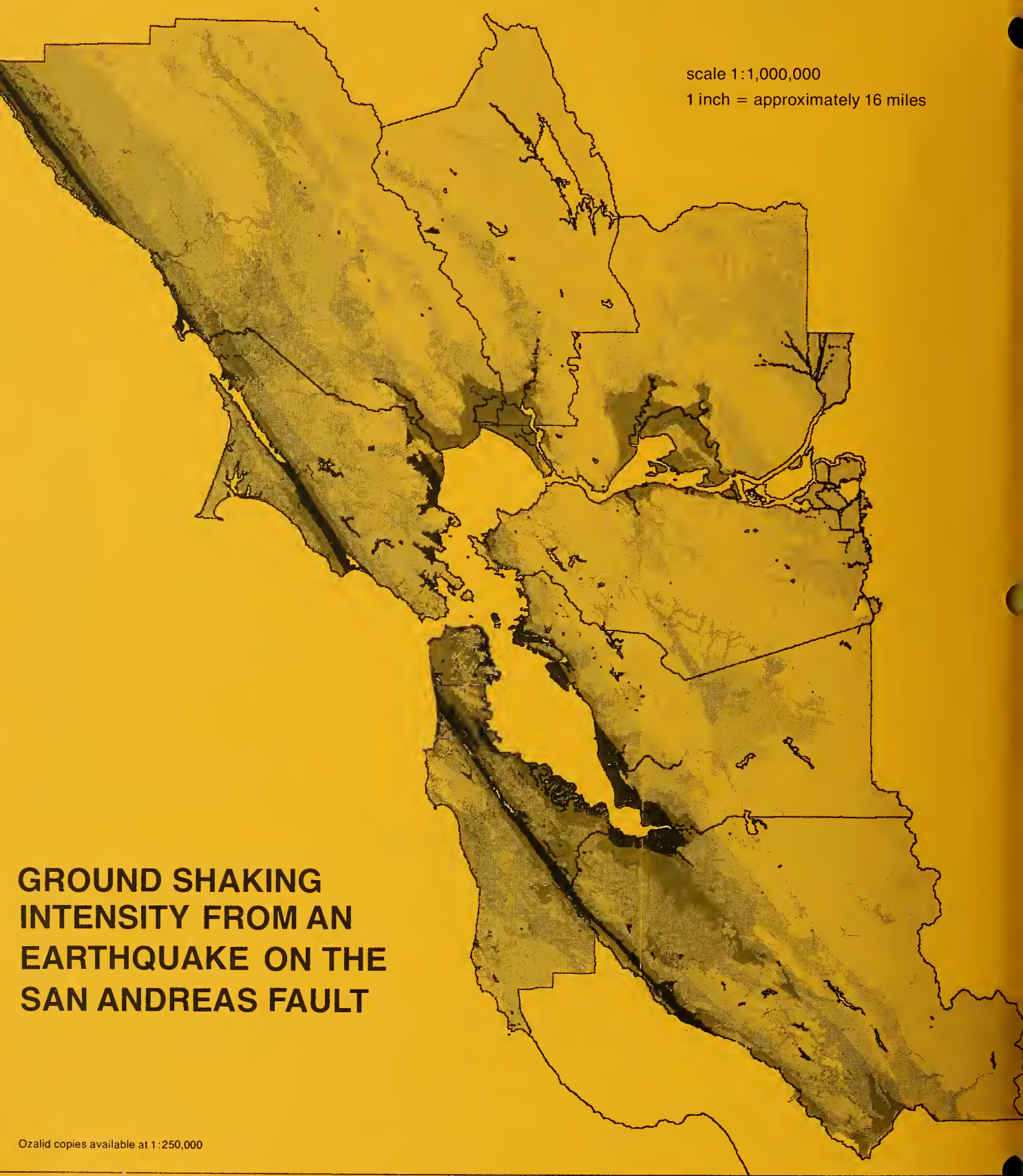
FURTHER INFORMATION ON THIS FILE IS CONTAINED IN:

- o Working Paper #17: Using Earthquake Intensity and Related Damage to Estimate Maximum Earthquake Intensity and Cumulative Damage Potential From Earthquake Ground Shaking

The general method is from USGS Professional Paper 941-A (Borcherdt and others)

LIMITATIONS AND FUTURE PLANS:

The intensity data are mapped using the San Francisco intensity scale rather than the more commonly used modified Mercali intensity scale for they are based on an empirical method developed using data from the San Francisco earthquake of 1906. Using a different attenuation relationship (such as that developed by Evernden and others at USGS) and using the modified Mercali intensity scale should change the appearance of these maps, especially near the source faults.



scale 1:1,000,000
1 inch = approximately 16 miles

GROUND SHAKING INTENSITY FROM AN EARTHQUAKE ON THE SAN ANDREAS FAULT

Ozalid copies available at 1:250,000

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MAXIMUM GROUND SHAKING INTENSITY

HAZARD MAP FILE

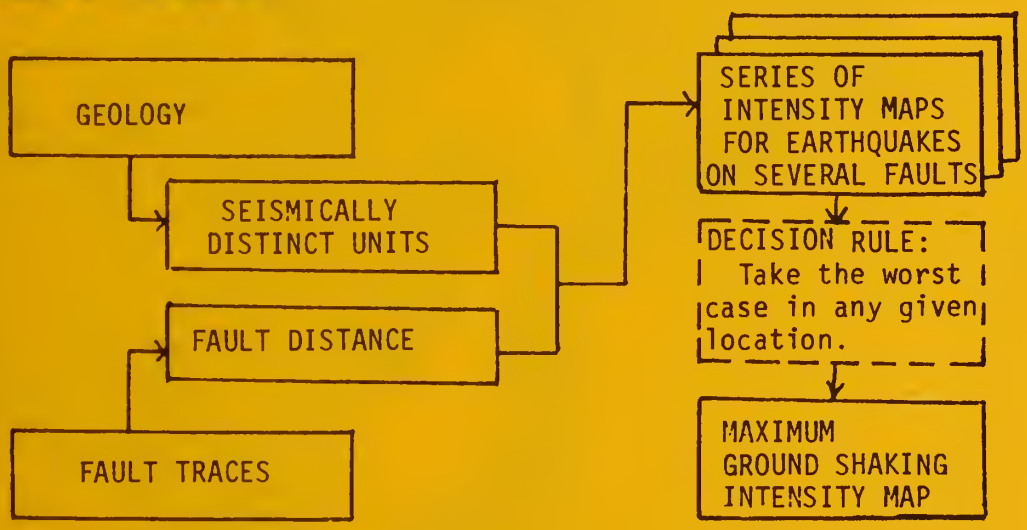
COVERAGE: All nine Bay Area counties in great detail

SOURCE: The basic data map files on faults and geology are combined to produce this map using data on:

- o maximum magnitude for each fault
- o maximum intensity associated with each maximum magnitude
- o the attenuation of intensity with distance from the fault rupture
- o the effect of local geology on that intensity

December 1983
Hectare resolution

DIAGRAM OF COMPONENTS:

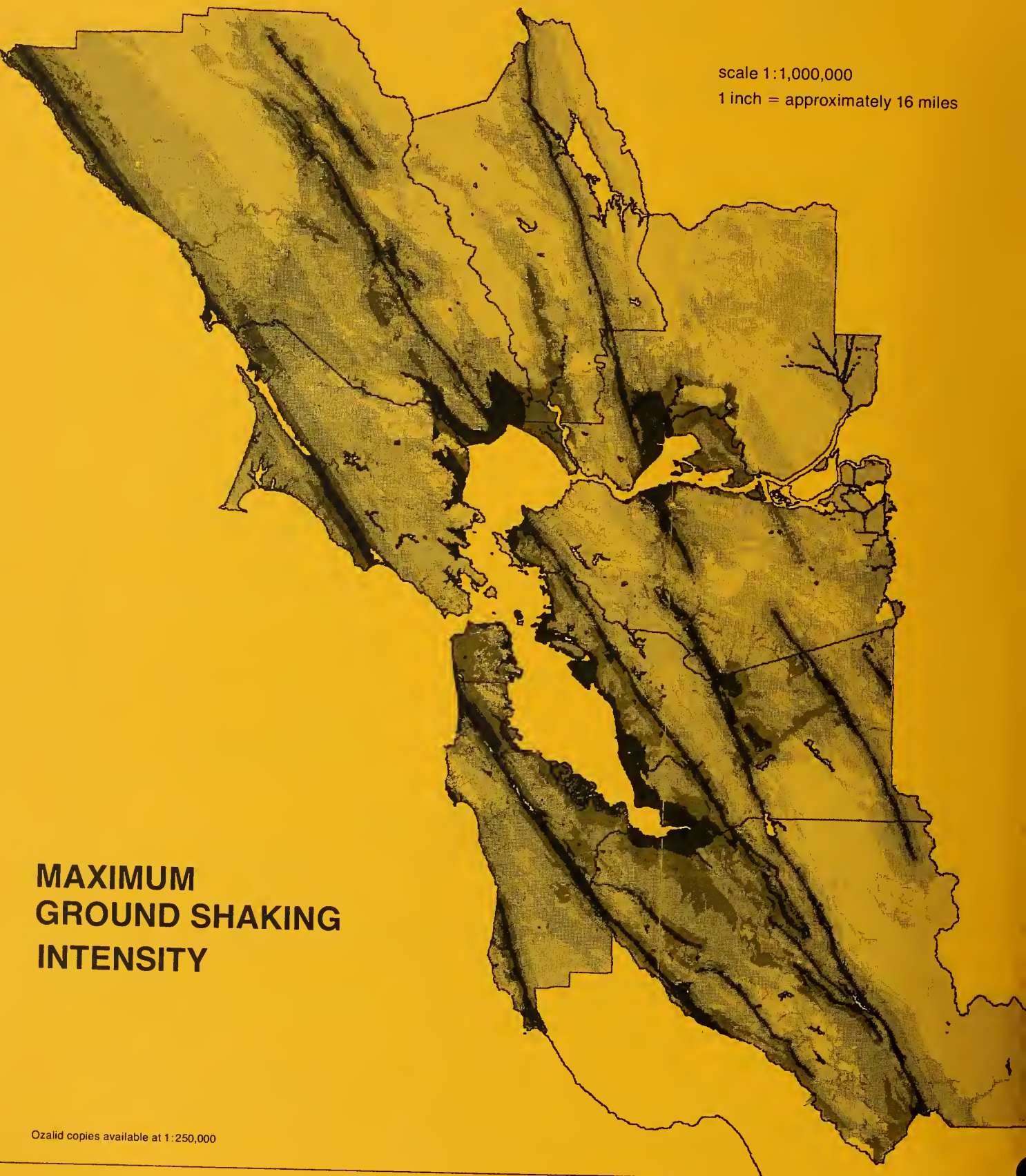


FURTHER INFORMATION ON THIS FILE IS CONTAINED IN:

- o Working Paper #9: Earthquake Map Applications for Composite Earthquake Hazard Mapping
- o Working Paper #17: Using Earthquake Intensity and Related Damage to Estimate Maximum Earthquake Intensity and Cumulative Damage Potential From Earthquake Ground Shaking

LIMITATIONS AND FUTURE PLANS:

The intensity data are mapped using the San Francisco intensity scale rather than the more commonly used modified Mercali intensity scale for they are based on an empirical method developed using data from the San Francisco earthquake of 1906. Using a different attenuation relationship (such as that developed by Evernden and others at USGS) and using the modified Mercali intensity scale should change the appearance of these maps, especially near the source faults.



scale 1:1,000,000
1 inch = approximately 16 miles

MAXIMUM GROUND SHAKING INTENSITY

Ozalid copies available at 1:250,000

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CUMULATIVE DAMAGE POTENTIAL FROM EARTHQUAKE GROUND SHAKING

HAZARD MAP FILE

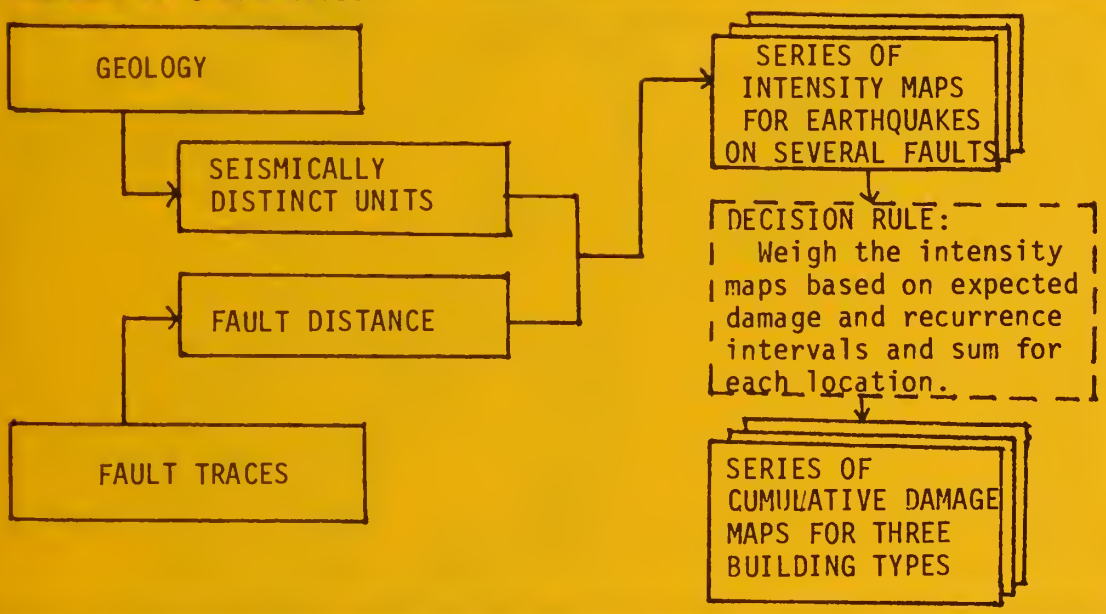
COVERAGE: All nine Bay Area counties in great detail

SOURCE: The basic data map files on faults and geology are combined to produce this map using data on:

- o frequency of different magnitudes of earthquakes on each fault
- o damage associated with each intensity
- o the source data used in the maximum ground shaking intensity file
- o the effect of local geology on that intensity

December 1983
Hectare resolution

DIAGRAM OF COMPONENTS:



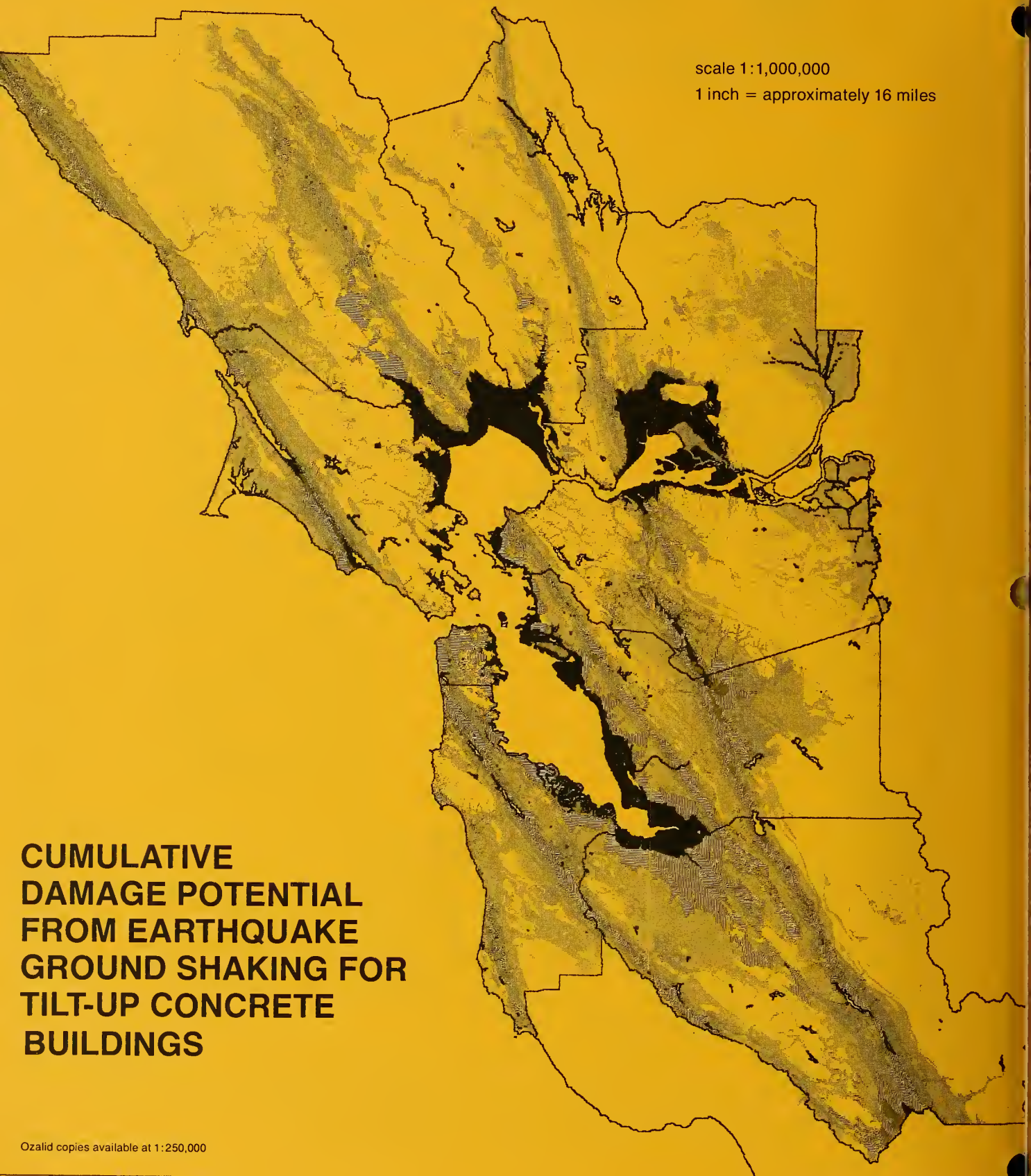
FURTHER INFORMATION ON THIS FILE IS CONTAINED IN:

- o Working Paper #17: Using Earthquake Intensity and Related Damage to Estimate Maximum Earthquake Intensity and Cumulative Damage Potential From Earthquake Ground Shaking

The general method is a refinement of a technique described in an earlier ABAG publication, Earthquake Intensity and Expected Cost (1978).

LIMITATIONS AND FUTURE PLANS:

Better data on recurrence intervals of various magnitudes of earthquakes and on the long term slip rate of faults would improve the reliability of the file. The damage data and resulting risk data are statistical and can be applied to buildings for comparison only.



scale 1:1,000,000
1 inch = approximately 16 miles

CUMULATIVE DAMAGE POTENTIAL FROM EARTHQUAKE GROUND SHAKING FOR TILT-UP CONCRETE BUILDINGS

Ozalid copies available at 1:250,000

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FAULT STUDIES ZONES

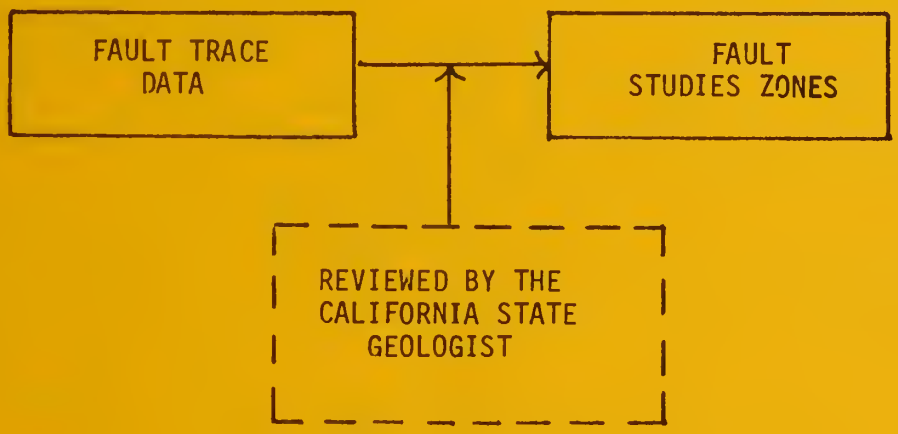
HAZARD MAP FILE

COVERAGE: All nine Bay Area counties

SOURCE: The data on fault traces were used by the California State Geologist to designate zones approximately 1/4 mile wide where geologic investigations are required to avoid building on active faults due to the hazard of surface rupture. This process is pursuant to the Alquist-Priolo Special Studies Zones Act.

December 1983
Hectare resolution

DIAGRAM OF COMPONENTS:

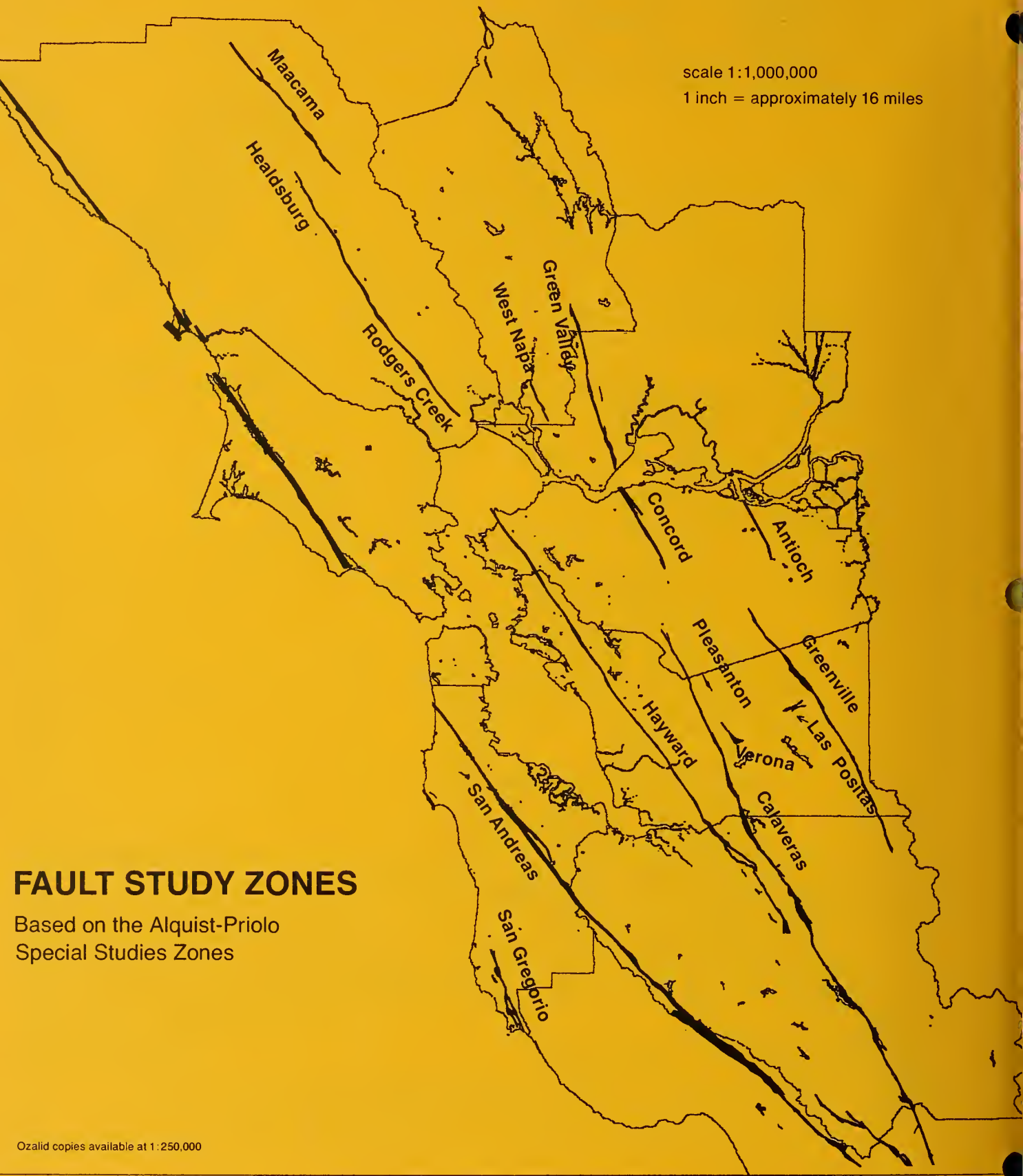


FURTHER INFORMATION ON THIS FILE IS CONTAINED IN:

- o Working Paper #9: Earthquake Map Applications for Composite Earthquake Hazard Mapping
- o Working Paper #17: Using Earthquake Intensity and Related Damage to Estimate Maximum Earthquake Intensity and Cumulative Damage Potential From Earthquake Ground Shaking

LIMITATIONS AND FUTURE PLANS:

As new information on fault activity becomes available, California Division of Mines and Geology staff will modify the maps used as a basis for this file. The hazard file should be modified accordingly.



FAULT STUDY ZONES

Based on the Alquist-Priolo
Special Studies Zones

Ozalid copies available at 1:250,000

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WORKING PAPERS
(as of December 1983)

The working papers referenced in this guide are not automatically included in this document. They can be ordered from ABAG's offices at a small charge. This user's guide, complete with all Working Papers, has automatically been forwarded to the planning director in each city and county in the Bay Area.

The available working papers include:

#1 - Faults and Ground Shaking Intensity -- replaced by Working Paper #17

#2 - Attenuation, Geologic Materials and Ground Shaking -- replaced by Working Paper #17

#3 - Damage and Ground Shaking Intensity -- replaced by Working Paper #17

#4 - Liquefaction Potential Mapping -- a description of the likelihood of finding cohesionless sediments within a geologic map unit, the likelihood that those sediments (when saturated) would be susceptible to liquefaction, the likelihood of finding those sediments saturated, and liquefaction opportunity (based on recurrence intervals of earthquakes and the distance from various faults at which liquefaction can occur)

#5 - Slope Stability Mapping -- a description of how slope, geology and existing landslides can be used to estimate landslide susceptibility in an earthquake and under more normal circumstances in San Mateo County

#6 - Tsunami Inundation Areas -- a description of the data used to develop a tsunami hazard map and of the relative risk associated with tsunamis

#7 - Dam Inundation Areas -- a description of dam inundation mapping and of the relative risk associated with dam failure

#8 - Earthquake Map Applications for Automated Environmental Impact Assessment -- a description of how hazard map files can be used to produce a background document for development proposals that can be incorporated into an Environmental Impact Report

#9 - Earthquake Map Applications for Composite Earthquake Hazard Mapping -- a description of how the various hazard maps can be combined to yield two types of hazard maps of total earthquake associated damage

#10 - Earthquake Map Applications for Automated Assessment of Property and Population at Risk -- a description of how tables of area in cities, counties, census tracts and land use types can be created for each hazard map category, as well as some sample tables with a discussion of the conclusions that can be formed. In addition, the feasibility of disaggregating census tract data on population using land use to create data on population at risk in various hazard categories is discussed.

#11 - The Method Developed to Extend Detailed Map Information Beyond San Mateo County to Selected Areas of Significant Development Pressure -- a description of the process used to select the areas of development pressure, the refinements and extensions of the geology, landslide, and topography files, and the extensions of the intensity maps, landslides susceptibility maps, and composite maps to the Petaluma and ridgelands areas. (The intensity map discussion is superceded by Working Paper #17.)

#12 - Ordering and Using Earthquake Hazard Maps in Local General Plans -- a description of the types of maps available, their relationship to maps recommended for inclusion in local plans by the State Office of Planning and Research General Plan Guidelines, and the scale and form in which those maps are available

#13 - Automated Environmental Impact Assessment - An Update -- a description of the revised setting and impacts section and an extensive description of possible mitigation measures

#14 - Using Earthquake Hazard Maps for Site Screening and Anticipating Mitigation Benefits and Costs -- a description of the use of these maps for pointing to areas that should be easier to develop in a safe manner, as well as for warning of the costs associated both with potential damage and with necessary hazard mitigation

#15 - Assessment of Current and Projected Property and Population at Risk - An Update -- a description of tabulations of population at risk, rather than land area, the issues surrounding the development of a risk map based on existing building types, comparisons of various methods of estimating earthquake losses, and comparisons of existing and projected risk. San Mateo County is used as a study area.

#16 - Detailed Map Information for Selected Existing Urbanized Areas and Landslide Susceptibility Hazard Map Refinement -- a description of the methods for choosing those areas for additional detailed hazard mapping, extending the bedrock geology, landslide and topography files to them, and producing the landslide susceptibility maps for the central Bay Area

#17 - Using Earthquake Intensity and Related Damage to Estimate Maximum Earthquake Intensity and Cumulative Damage Potential from Earthquake Ground Shaking -- a description of the general data needed to produce the series of individual intensity maps and the additional data needed to combine these maps to produce either a maximum intensity map or maps showing risk of damage (revised in December 1983)

#18 - Using Earthquake Hazard Maps to Analyze the Vulnerability of Lifeline System Locations -- a description of ABAG's use of its mapping capabilities to gather information on the location of hazardous areas relative to key lifeline system components